

OÖLITES OR CAVE PEARLS IN THE CARLSBAD CAVERNS

By FRANK L. HESS¹

Custodian of Rare Metals and Rare Earths, United States National Museum

In 1925 Dr. Willis T. Lee, of the United States Geological Survey, collected a considerable number of oölites from Carlsbad, N. Mex. They included little round balls of considerable range in size, to which he gave the somewhat fanciful name of "cave pearls." They were found in small, round, shallow pools, and some resembled eggs in a bird's nest (figs. 1 and 2, pl. 1); others looked like a quantity of stone shot. Still others of the oölites were irregular in shape, and were as much as 2 inches (50 mm.) long, and less thick. So far as known to me, this is the first time that oölites have been found in a cave, though they are common in other places. Excellent examples are on exhibition in the United States National Museum, and their study throws an excellent light on the formation of oölites in general.

By "oölite" is ordinarily meant a tiny, more or less rounded concretion formed of concentric layers of mineral matter. When these are massed together they resemble fish roe—hence the name "oölite," from the Greek *oön*, meaning egg.

The oölites collected by Mr. Lee range in diameter from one-sixteenth of an inch (1.5 mm.) to a little more than an inch (25 to 30 mm.). Most of them are round, some are oval, and some irregular in shape. Their surfaces vary as much as their forms. Some are beautifully polished and opaque, and others, particularly the smaller, are smooth and translucent, resembling little balls of artificially polished onyx. (See pl. 1, fig. 1.) Some have the texture of bisque, others are much rougher. Though most are white, others have a slight yellowish tint or may be clouded with yellow.

¹ Since this article was written I have found a description of irregular, smaller oölites which were discovered in a Swedish mine. (Erdmann, Edv. Stalagmit och pisolitartade bildningar i Höganäs stenokolsgrufa, Shone. Geol. Fören Förhändl., Stockholm, vol. 24, 1902, pp. 501–507, 5 pho. reps.) The illustrations show well the formation of irregular pisolites by dripping calcium carbonate (CaCO_3) bearing water (H_2O).

Their inner structure in general is similar, though differing in detail. Sections were prepared for microscopic study of three round oölites, each a little more than half an inch in diameter. These are shown magnified $4\frac{1}{3}$ diameters in Plate 2. In each oölite there may be observed a nuclear mass surrounded by a broader noticeably radial zone of more coarsely crystalline material surrounded by circumferential rings of very fine texture. The rings differ in number, thickness, and continuity in the three specimens.

The coarser part of the oölites is certainly calcite, and not aragonite, as might be supposed. The dense rings are apparently also calcite, though their mineral composition is difficult to determine.

The nuclei, too, are all floccules of calcite—aggregates that formed within the little pools as these became supersaturated with calcium carbonate. Drops collecting on the ends of the stalactites above pools begin to lose carbon dioxide, and as they drip and splash into the pool lose enough more to become supersaturated with calcium carbonate, and thus to set free molecules, which begin a separate existence. These molecules attaching themselves to other molecules in the little eddies of a tiny pool form a spherical body. They must have been kept in sufficient motion to maintain this form as they increased in size. The movement of the water caused by the splash of falling drops was probably sufficient. In much the same way oölitic sands have formed on the bottom of Great Salt Lake near the shore, though the grains are very much smaller than the smallest collected in Carlsbad Caverns and average only about one one-hundredth of an inch (0.4 mm.) in diameter. (See pl. 3.) The streams that flow from the great limestone beds of the Wasatch Mountains carry large quantities of calcium carbonate in solution to the lake. Here calcite is precipitated from the supersaturated waters as it is in the tiny pools of Carlsbad Cavern, but in many of the oölites tiny grains of sand form the nuclei. As the lake waters move over the bottom, calcium carbonate is added to the oölites already formed or new ones are started. The size of the oölites is probably closely related to the amount of their movement after they are formed.

Similarly the great oölitic limestone beds of the world have been formed. They are of many geologic ages and are very widely distributed. In this country the oölitic limestone quarried at Bedford, Ind., is one of our best-known building stones and is shipped to all parts of the United States.

Oölites are formed from supersaturated solutions other than those containing calcium carbonate. The great phosphate deposits of Utah, Idaho, Wyoming, and Montana contain abundant oölites of phosphorite—a calcium phosphate containing more or less fluorine

and chlorine. A specimen of phosphate rock from Idaho is shown in Plate 4. Some deposits of iron carbonate have perhaps been laid down in the same way and later recrystallized, so that their oölitic structure is indistinct. The great beds of oölitic iron ores probably have been precipitated in a similar manner. In at least three small crater lakes of Japan, where the water is agitated by sulphurous gases, oölites of sulphur are formed, and in one of them in great enough quantity to be profitably exploited.²

Nor is the formation of oölites confined to solutions in liquids. Precipitation of a substance from any moving fluid, such as air or other gases, may produce solids of the same type. In the Mond process of obtaining nickel from its ores the nickel is converted to nickel carbonyl, a gas, and advantage is taken of the principle that substances precipitating in an agitated fluid may be collected as oölites. The gas is run into a reductor and heated somewhat above its decomposition point. Fine granules of nickel are rolled through the decomposing gas and as the nickel separates from the gas it collects on the granules, and thus, metallic balls, true nickel oölites, are formed. (See pl. 5.) Thousands of tons of nickel are annually obtained by this process.

Hailstones are probably formed according to the same principle. A number of snowflakes are matted together by swirling air, or a group of other ice molecules are collected together, and on the mass as a nucleus ice is deposited directly from gaseous water in an atmosphere below the freezing point, making concentric shells very similar in their structure to calcite oölites till hail finally falls as the familiar enemy of crops and greenhouses. Cross sections of large hailstones are very similar to the cross sections of oölites from Carlsbad Caverns, shown in Plates 6 and 7.³ Oölites of calcite are formed in boiling sugar refinery refuse in the process of making by-product alcohol. They are formed rapidly and are fairly large, 1½ inches or more in longest diameter. Those seen are of coarse texture and do not have smooth surfaces.

The dense and the more visibly crystalline layers or shells in the oölites from Carlsbad Caverns have evidently formed under different conditions and the dense polished layers are probably formed by slow, steady accretion.

Some of the oölites from Carlsbad Caverns are elongated or otherwise vary from a spherical form. (See pls. 7 and 8.) Their form is largely determined by that of the nucleus. An elongated oölite, shown in polished section in Plate 5, Figure 1, tells its own story.

² Oinouye, Y., A peculiar process of sulphur deposition, *Journal of Geology*, vol. 24, 1916, pp. 806-808.

³ A good illustration of hailstones showing concentric structure and radial crystallization is given in "*Lehrbuch der Meteorologie*," by Jul. von Hann, Leipzig, 1915, pl. 25, opposite page 708.

The nucleus here was a fragment of a small stalactite. In the same way many of the oölites of phosphate contain a small tooth or some other fragment as a nucleus. (Pl. 4.) Other elongated oölites in process of formation are shown in Plates 7 and 8.

The rough surfaces on some of the oölites are probably due to a partial drying up of the pools, when the calcite was deposited from a film of water, as on the stalactites. Such oölites soon become attached to the floor. Likewise whenever the drip of the water becomes too small to move the oölites with its splash, or whenever the oölites grow too large to be moved by the splash of the drip that formed them, they also become attached to the bottom, and gradually **lose their individual form, coalesce, and form a lumpy floor.** Even on the round oölites, which were presumably formed under conditions most favorable for symmetrical growth, deposition did not take place quite uniformly over the whole surface (see pl. 2) and probably means that the asymmetrical deposition took place while the nuclei were quiescent.

Efforts have been made to show that oölites are formed as the result of microbic or other unusual influences, but the oölites of nickel and of sulphur, hailstones, and oölites formed in boiling sugar refuse seem to make it unnecessary to assume other causes for their formation than moving supersaturated fluids. We may wonder why oölites are not formed in more places where limestones of different kinds are deposited, but most limestones are formed, not by precipitation from solution, but through the accumulation of definite preexisting particles. Some limestones, like the Indiana rock, show a combination of the two processes. The nonoölitic limestones, which have been deposited from solution, have probably formed where there has been insufficient motion or insufficient depth of water to make oölites.

EXPLANATION OF PLATES

PLATE 1

FIG. 1. Oölites or cave pearls from the Rookery in Carlsbad Cavern, New Mexico. These sometimes have a surface resembling ground glass and sometimes smooth as if polished.

2. A so-called bird's nest, a shallow depression with pearls like eggs in a nest.

PLATE 2

Sections through the centers of three spherical oölites; note variation in bands of growth.

PLATE 3

Sections of oölitic sand from Great Salt Lake, Utah. Streams from the mountain bring calcium carbonate in solution which is precipitated in the lake. Small particles of sand often form the nuclei of the oölites.

PLATE 4

Section of a phosphate rock from Wyoming, showing oölitic structures. In one instance a fish tooth forms the nucleus of an oölite.

PLATE 5

FIGS. 1 and 2. Elongated oölitic structures from the Rookery. The one at the right sliced and showing a nucleus of a broken stalactite.

3. Section of an oölite of nickel formed by accretion from decomposing nickel carbonyl.

PLATE 6

FIG. 1. Hailstones showing concentric structure.

2. Oölite from cave showing a similar concentric structure.

PLATES 7 AND 8

Oölitic structures of varying shapes formed under varying conditions.